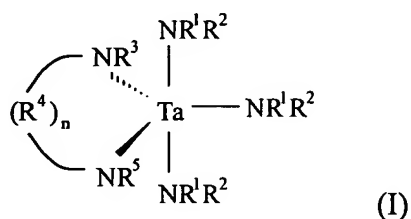


THE CLAIMS

What is claimed is:

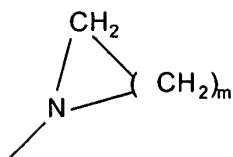
1. A precursor composition comprising at least one tantalum species selected from the group consisting of:

- (i) tethered amine tantalum complexes of the formula (I):



wherein:

each of R^1 , R^2 , R^3 and R^5 is independently selected from the group consisting of H, C₁-C₄ alkyl, silyl, C₃-C₈ cycloalkyl, C₁-C₄ alkylsilyl, C₆-C₁₀ aryl and nitrogen-containing groups such as NR^6R^7 , wherein R^6 and R^7 are the same as or different from one another and each is independently selected from the group consisting of H, C₁-C₄ alkyl, and C₃-C₈ cycloalkyl, or alternatively NR^1R^2 may be represented by the molecular moiety

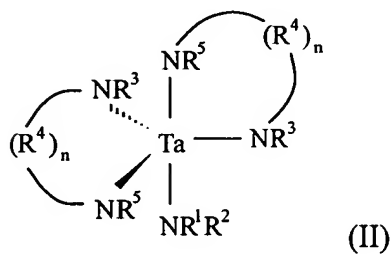


wherein $m = 1, 2, 3, 4, 5$ or 6 ;

R^4 is selected from the group consisting of C_1 - C_4 alkylene, silylene ($-\text{SiH}_2-$), C_1 - C_4 dialkylsilylene and NR^8 , wherein R^8 is selected from the group consisting of H , C_3 - C_8 cycloalkyl and C_1 - C_4 alkyl; and

n is $1, 2, 3$, or 4 , but where R^4 is silylene, C_1 - C_4 dialkylsilylene or NR^8 , n must be 1 ;

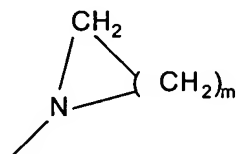
(ii) tethered amine tantalum complexes of the formula (II):



wherein:

each of R^1 , R^2 , R^3 and R^5 is independently selected from the group consisting of H , C_1 - C_4 alkyl, silyl, C_3 - C_8 cycloalkyl, C_1 - C_4 alkylsilyl, C_6 - C_{10} aryl and

nitrogen-containing groups such as NR^6R^7 , wherein R^6 and R^7 are the same as or different from one another and each is independently selected from the group consisting of H, $\text{C}_1\text{-C}_4$ alkyl, and $\text{C}_3\text{-C}_8$ cycloalkyl, or alternatively NR^1R^2 may be represented by the molecular moiety



wherein $m = 1, 2, 3, 4, 5$ or 6 ;

R^4 is selected from the group consisting of $\text{C}_1\text{-C}_4$ alkylene, silylene ($-\text{SiH}_2-$), $\text{C}_1\text{-C}_4$ dialkylsilylene and NR^8 , wherein R^8 is selected from the group consisting of H, $\text{C}_3\text{-C}_8$ cycloalkyl and $\text{C}_1\text{-C}_4$ alkyl; and

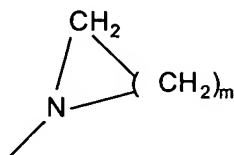
n is 1, 2, 3, or 4, but where R^4 is silylene, $\text{C}_1\text{-C}_4$ dialkylsilylene or NR^8 , n must be 1; and

(iii) tantalum amide compounds of the formula (III):



wherein:

each of $R^1 - R^4$ is independently selected from the group consisting of C_1 - C_4 alkyl, silyl, C_3 - C_8 cycloalkyl, C_1 - C_4 alkylsilyl, C_6 - C_{10} aryl, or alternatively NR^1R^2 or NR^3R^4 may be represented by the molecular moiety

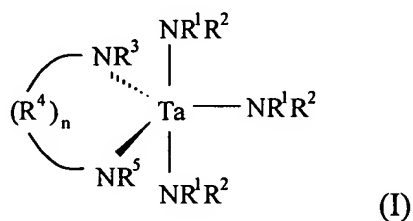


wherein $m = 1, 2, 3, 4, 5$ or 6 ; and

n is $1, 2, 3$, or 4 .

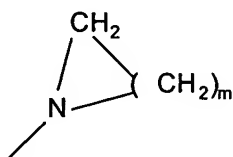
2. The precursor composition of claim 1, further comprising a solvent for said tantalum species.
3. The precursor composition of claim 2, wherein said solvent comprises a solvent species selected from the group consisting of C_6 - C_{10} alkanes, C_6 - C_{10} aromatics, and compatible mixtures thereof.
4. The precursor composition of claim 2, wherein said solvent comprises a solvent species selected from the group consisting of hexane, heptane, octane, nonane, decane, toluene and xylene.
5. The precursor composition of claim 1, comprising at least one tethered amine tantalum complex of formula (I).

6. The precursor composition of claim 1, comprising at least one tethered amine tantalum complex of formula (II).
7. The precursor composition of claim 1, comprising at least one tantalum amide compound of formula (III).
8. η^2 -N,N'-dimethylethylenediamino-tris-dimethylaminotantalum.
9. Bis-diethylamino-tris-dimethylaminotantalum.
10. η^2 -N,N'-diethylethylenediamino-tris-dimethylaminotantalum.
11. η^2 -N,N'-dimethylpropanediamino-tris-dimethylaminotantalum.
12. A method of forming Ta material on a substrate from a precursor, comprising vaporizing said precursor to form a precursor vapor, and contacting the precursor vapor with the substrate to form said Ta material thereon, wherein the precursor comprises at least one tantalum species selected from the group consisting of:
 - (i) tethered amine tantalum complexes of the formula (I):



wherein:

each of R^1 , R^2 , R^3 and R^5 is independently selected from the group consisting of H, C_1 - C_4 alkyl, silyl, C_3 - C_8 cycloalkyl, C_1 - C_4 alkylsilyl, C_6 - C_{10} aryl and nitrogen-containing groups such as NR^6R^7 , wherein R^6 and R^7 are the same as or different from one another and each is independently selected from the group consisting of H, C_1 - C_4 alkyl, and C_3 - C_8 cycloalkyl, or alternatively NR^1R^2 may be represented by the molecular moiety

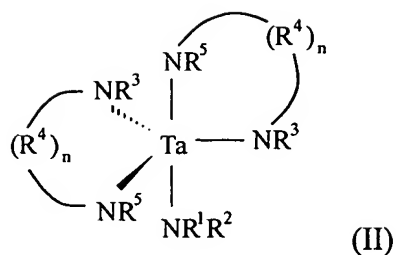


wherein $m = 1, 2, 3, 4, 5$ or 6 ;

R^4 is selected from the group consisting of C_1 - C_4 alkylene, silylene ($-\text{SiH}_2-$), C_1 - C_4 dialkylsilylene and NR^8 , wherein R^8 is selected from the group consisting of H, C_3 - C_8 cycloalkyl and C_1 - C_4 alkyl; and

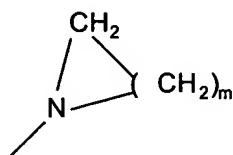
n is 1, 2, 3, or 4, but where R^4 is silylene, C_1 - C_4 dialkylsilylene or NR^8 , n must be 1;

(ii) tethered amine tantalum complexes of the formula (II):



wherein:

each of R^1 , R^2 , R^3 and R^5 is independently selected from the group consisting of H, C₁-C₄ alkyl, silyl, C₃-C₈ cycloalkyl, C₁-C₄ alkylsilyl, C₆-C₁₀ aryl and nitrogen-containing groups such as NR^6R^7 , wherein R^6 and R^7 are the same as or different from one another and each is independently selected from the group consisting of H, C₁-C₄ alkyl, and C₃-C₈ cycloalkyl, or alternatively NR^1R^2 may be represented by the molecular moiety



wherein $m = 1, 2, 3, 4, 5$ or 6 ;

R^4 is selected from the group consisting of C₁-C₄ alkylene, silylene ($-\text{SiH}_2-$), C₁-C₄ dialkylsilylene and NR^8 , wherein R^8 is selected from the group consisting of H, C₃-C₈ cycloalkyl and C₁-C₄ alkyl; and

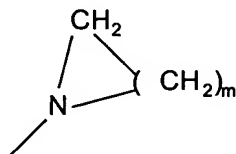
n is 1, 2, 3, or 4, but where R^4 is silylene, C₁-C₄ dialkylsilylene or NR^8 , n must be 1; and

(iii) tantalum amide compounds of the formula (III):



wherein:

each of $R^1 - R^4$ is independently selected from the group consisting of C_1 - C_4 alkyl, silyl, C_3 - C_8 cycloalkyl, C_1 - C_4 alkylsilyl, C_6 - C_{10} aryl, or alternatively NR^1R^2 or NR^3R^4 may be represented by the molecular moiety



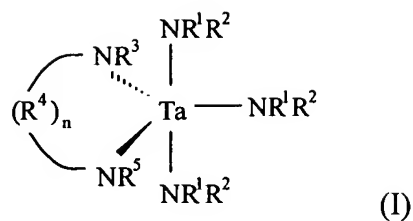
wherein $m = 1, 2, 3, 4, 5$ or 6 ; and

n is $1, 2, 3$, or 4 .

13. The method of claim 12, wherein said material formed on the substrate is TaN.
14. The method of claim 12, wherein the precursor composition further comprises a solvent for said tantalum species.
15. The method of claim 14, wherein said solvent comprises a solvent species selected from the group consisting of C_6 - C_{10} alkanes, C_6 - C_{10} aromatics, and compatible mixtures thereof.

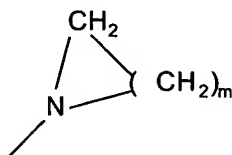
16. The method of claim 12, wherein said solvent comprises a solvent species selected from the group consisting of hexane, heptane, octane, nonane, decane, toluene and xylene.
17. The method of claim 12, comprising liquid delivery chemical vapor deposition of the Ta material.
18. The method of claim 12, comprising deposition of said Ta material on said substrate by a technique selected from the group consisting of chemical vapor deposition and atomic layer deposition.
19. The method of claim 12, wherein the substrate comprises a microelectronic device structure.
20. The method of claim 19, wherein said Ta material comprises TaN or TaSiN.
21. The method of claim 20, further comprising metalizing said substrate after deposition of said Ta material thereon.
22. The method of claim 20, further comprising forming a ferroelectric thin film on the substrate.
23. The method of claim 12, wherein said Ta material comprises TaN.
24. The method of claim 12, wherein said Ta material comprises Ta₂O₅.
25. The method of claim 12, wherein said Ta material comprises BiTaO₄.

26. The method of claim 12, comprising liquid delivery chemical vapor deposition of said precursor to form TaN on the substrate.
27. The method of claim 26, further comprising metallizing the substrate with copper.
28. The method of claim 26, further comprising forming a ferroelectric thin film on the substrate.
29. The method of claim 12, wherein the precursor composition comprises η^2 -N,N'-dimethylethylenediamino-tris-dimethylaminotantalum.
30. The method of claim 12, wherein the precursor composition comprises bis-diethylamino-tris-dimethylaminotantalum.
31. The method of claim 12, wherein the precursor composition comprises η^2 -N,N'-diethylethylenediamino-tris-dimethylaminotantalum.
32. The method of claim 12, wherein the precursor composition comprises η^2 -N,N'-dimethylpropanediamino-tris-dimethylaminotantalum.
33. The method of claim 12, comprising liquid delivery chemical vapor deposition.
34. A process for making a tantalum complex of formula (I):



wherein:

each of R^1 , R^2 , R^3 and R^5 is independently selected from the group consisting of H, C₁-C₄ alkyl, silyl, C₃-C₈ cycloalkyl, C₁-C₄ alkylsilyl, C₆-C₁₀ aryl and nitrogen-containing groups such as NR^6R^7 , wherein R^6 and R^7 are the same as or different from one another and each is independently selected from the group consisting of H, C₁-C₄ alkyl, and C₃-C₈ cycloalkyl, or alternatively NR^1R^2 may be represented by the molecular moiety

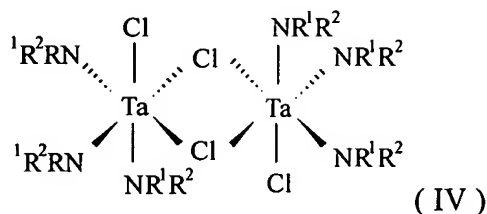


wherein $m = 1, 2, 3, 4, 5$ or 6 ;

R^4 is selected from the group consisting of C₁-C₄ alkylene, silylene ($-\text{SiH}_2-$), C₁-C₄ dialkylsilylene and NR^8 , wherein R^8 is selected from the group consisting of H, C₃-C₈ cycloalkyl and C₁-C₄ alkyl; and

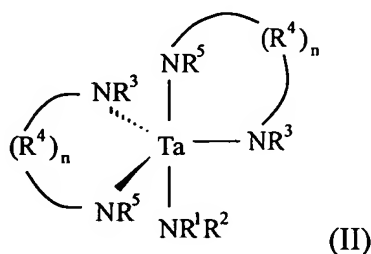
n is 1, 2, 3, or 4, but where R^4 is silylene, C₁-C₄ dialkylsilylene or NR^8 , n must be 1;

said process comprising reacting a compound of formula (IV) with $\text{LiNR}^5(\text{R}^4)_n\text{NR}^3\text{Li}$:



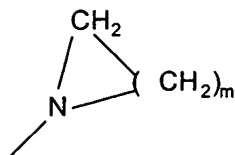
wherein $\text{R}^1 - \text{R}^5$ and n are as defined above.

35. A process for making a tantalum complex of formula II:



wherein:

each of R^1 , R^2 , R^3 and R^5 is independently selected from the group consisting of H, $\text{C}_1\text{-C}_4$ alkyl, silyl, $\text{C}_3\text{-C}_8$ cycloalkyl, $\text{C}_1\text{-C}_4$ alkylsilyl, $\text{C}_6\text{-C}_{10}$ aryl and nitrogen-containing groups such as NR^6R^7 , wherein R^6 and R^7 are the same as or different from one another and each is independently selected from the group consisting of H, $\text{C}_1\text{-C}_4$ alkyl, and $\text{C}_3\text{-C}_8$ cycloalkyl, or alternatively NR^1R^2 may be represented by the molecular moiety



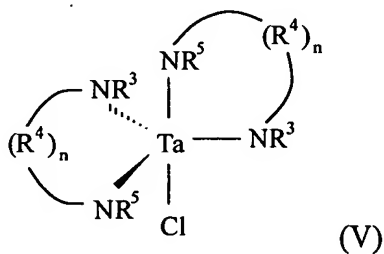
wherein $m = 1, 2, 3, 4, 5$ or 6 ;

R^4 is selected from the group consisting of C_1 - C_4 alkylene, silylene ($-\text{SiH}_2-$), C_1 - C_4 dialkylsilylene and NR^8 , wherein R^8 is selected from the group consisting of H , C_3 - C_8 cycloalkyl and C_1 - C_4 alkyl; and

n is $1, 2, 3$, or 4 , but where R^4 is silylene, C_1 - C_4 dialkylsilylene or NR^8 , n must be 1 ;

said process comprising

reacting TaX_5 with $\text{LiNR}^5(\text{R}^4)_n\text{NR}^3\text{Li}$ to yield a compound of formula (V):



wherein R^3 – R^5 and n are as defined above and $X = \text{Cl}, \text{Br}$ or I ; and

reacting the compound of formula (V) with $\text{LiN}(\text{R}^1\text{R}^2)$,

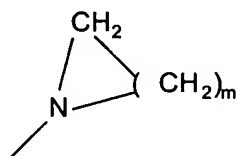
wherein R^1 and R^2 are as defined above.

36. A process for making a tantalum amide compound of the formula (III):



wherein:

each of $\text{R}^1 - \text{R}^4$ is independently selected from the group consisting of $\text{C}_1\text{-C}_4$ alkyl, silyl, $\text{C}_3\text{-C}_8$ cycloalkyl, $\text{C}_1\text{-C}_4$ alkylsilyl, $\text{C}_6\text{-C}_{10}$ aryl, or alternatively NR^1R^2 or NR^3R^4 may be represented by the molecular moiety

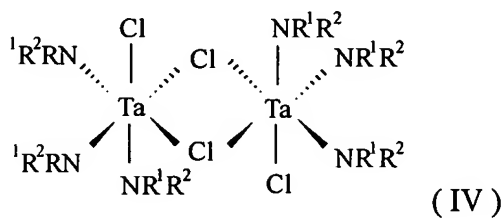


wherein $m = 1, 2, 3, 4, 5$ or 6 ; and

n is $1, 2, 3$, or 4 ;

said process comprising

reacting compound (IV) with LiNR^3R^4 :



wherein R^1 - R^4 are as defined above.